KANSAS STATE BOARD OF HEALTH

SEPTIC TANK SYSTEM FOR RURAL SEWAGE DISPOSAL

The Septic Tank System for Rural Sewage Disposal

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FOREWORD

The first edition of this Bulletin was prepared by the Division of Sanitation, State Board of Health, and the School of Engineering and Architecture, University of Kansas, for home owners living in unsewered rural areas who desired the convenience of modern bathrooms. Proper disposal of liquid wastes is necessary to prevent a nuisance and a menace to health.

In this, the fourth edition of this Bulletin, certain suggestions were made by the Engineering Extension Service of the Kansas State College. These suggestions are acknowledged with appreciation.

The material contained in this Bulletin has been prepared after careful study and is based on the results of many years' experience in home sewage-disposal problems. To insure complete success it is urged that installations be constructed strictly in accordance with the detailed plans and instructions provided. For large installations, engineering assistance should be obtained.

Additional copies of this Bulletin may be obtained free of charge by addressing the Kansas State Board of Health, Topeka, Kan.; Extension Service, Kansas State College, Manhattan, Kan.; or the School of Engineering and Architecture, University of Kansas, Lawrence, Kan.

The Septic Tank System for Rural Sewage Disposal

INTRODUCTION

The proper disposal of human wastes in suburban and rural districts not served by public sewers has long been recognized as one of the most important public health problems. Each year additional owners are making the necessary expenditures to equip their homes with modern bathrooms and running hot and cold water. These conveniences probably contribute more to the comfort of the home than any other improvement. The disposal of liquid wastes, without creating a nuisance and a menace to health, is often a difficult problem. Too frequently sewage disposal is considered as an afterthought, and makeshift facilities are resorted to in the interest of economy. These are almost always inadequate and expensive to maintain, and the ultimate expense to the home owner is greater than would have been the case had this portion of the improvement been carefully planned in the beginning.

Sewage wastes are dangerous because they may contain living organisms capable of creating disease. Typhoid fever and dysentery are the best known of the diseases of the digestive tract which are transmitted by sewage, although diarrhea and enteritis are other filth-borne diseases that are responsible for much sickness.

Infectious diseases of the digestive tract are contracted by taking the organisms into the body through the mouth with either food or drink. The problem, then, is the protection of food and drink against any possible chance of infectious contact with sewer wastes. Water is protected from such contacts by properly protecting the source of supply against sewage pollution, and, indirectly, the disposal of sewage in such manner that it cannot pollute wells and other supplies. It is also important to dispose of sewage wastes so that various insects, rodents, fowls and domestic animals will not come into contact with infectious material and thus enter a cycle that might result in the contamination of foodstuffs.

The use of cesspools as a means of sewage disposal is not recommended; and because of the sanitary hazards they frequently create, cesspools have been condemned by the Kansas State Board of Health. The public health rules and regulations of the Kansas State Board of Health prohibit the use of abandoned wells as cesspools.

Experience has shown that the most efficient installation for the disposal of sewage from individual dwellings and public buildings located in areas **where a public sewerage system cannot be made available** is an adequate septic tank with a properly designed field system for the disposal of the effluent. However, no individual design is applicable for universal adoption due to varying local conditions and types of soil encountered. Where only very restricted yard or lot areas are available, complications often develop. Tight clay soils also offer many perplexing problems regarding the safe and satisfactory disposal of the effluent. These problems often become serious

where a number of dwellings are contemplated on adjoining lots and where individual systems are proposed for subdivision developments.

The design of any individual sewage disposal system must take into consideration location with respect to wells or other sources of water supply, topography, soil conditions, area available, and maximum living capacity of the building served. Where soils are impervious and suitable unobstructed yard area is limited, consideration must be given to the construction of a public or community sewerage system rather than proceeding with the installation of individual systems which may prove unsatisfactory and become insanitary within a short period of time.

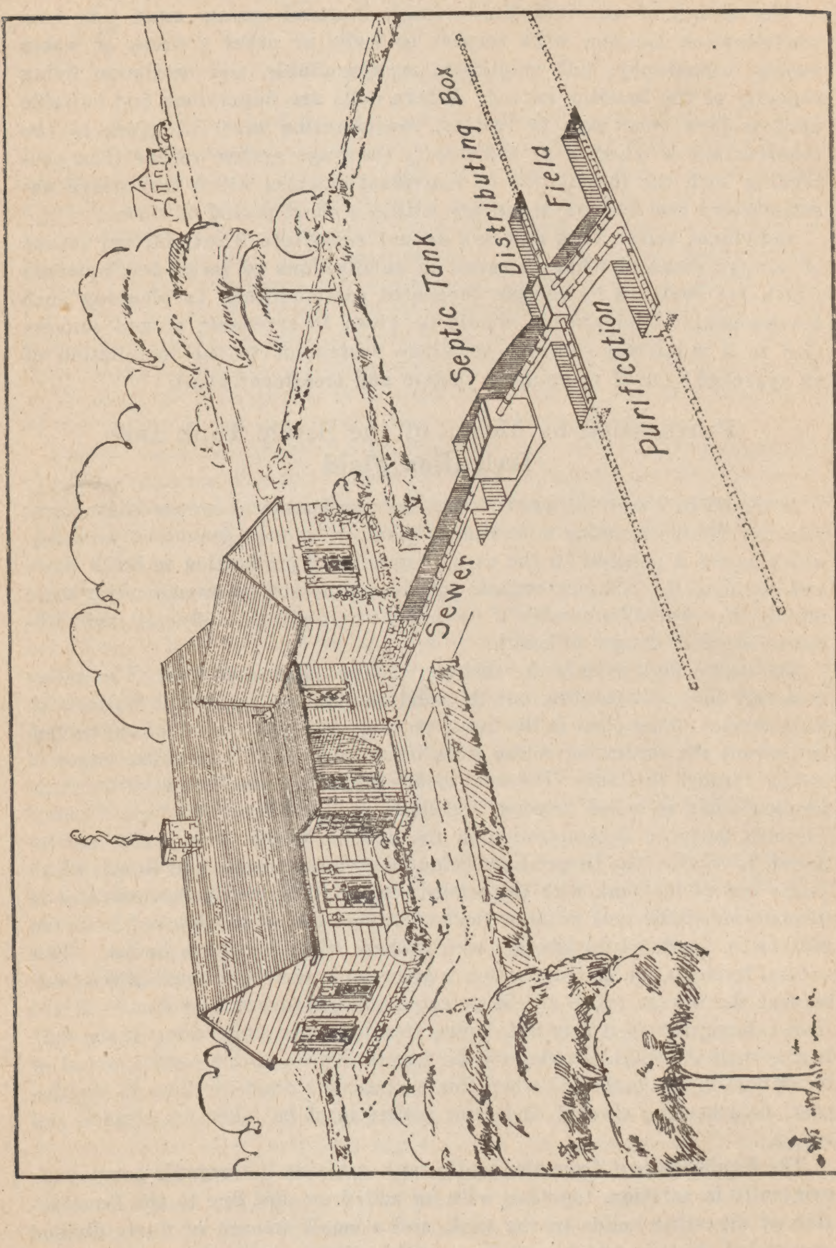
Individual septic tank systems do not constitute a satisfactory means of sewage disposal when installed in subdivisions or large developments which are destined to become congested communities. In planning such developments consideration should be given to extension of and connection to a municipal sanitary sewerage system or to the installation of an approved type of community system and treatment plant.

Purification by Means of the Septic Tank and Irrigation Field

It should be clearly understood that the purification of sewage is a natural process. By constructing a treatment plant we merely provide a workshop which makes it possible for the natural agencies of purification to break down and stabilize the complex organic substances present in sewage much more rapidly than would be possible if no thought were given to disposal, and without nuisance or danger to health.

The septic tank is only the first step in the disposal process. The action is merely that of separating out the solid material present in the waste, with little change taking place in the liquid portion. The tank must be large enough to prevent the separating action from being interrupted by sudden surges of sewage through the tank. The solid material settles to the bottom of the tank, forming what is called "sludge," or floats to the surface to form "scum." Through bacterial decomposition in the absence of air, these solids are reduced in volume, the by-products being gas, which escapes, and liquid, which passes out of the tank with the settled sewage. The residue accumulates in the bottom of the tank without further change, and when removed from the tank is an inert, earthy sludge, which when dried, resembles humus. This natural fermentation or putrefaction is going on in the septic tank all the time, so that the sewage solids are being continuously reduced in volume. If the tank is large enough it may not require cleaning for several years. If the tank is too small the solid particles will be forced through to the outlet instead of being held in the tank, and when this happens the drain-tile lines in the disposal field become clogged, and after a time must be taken up, cleaned and relaid.

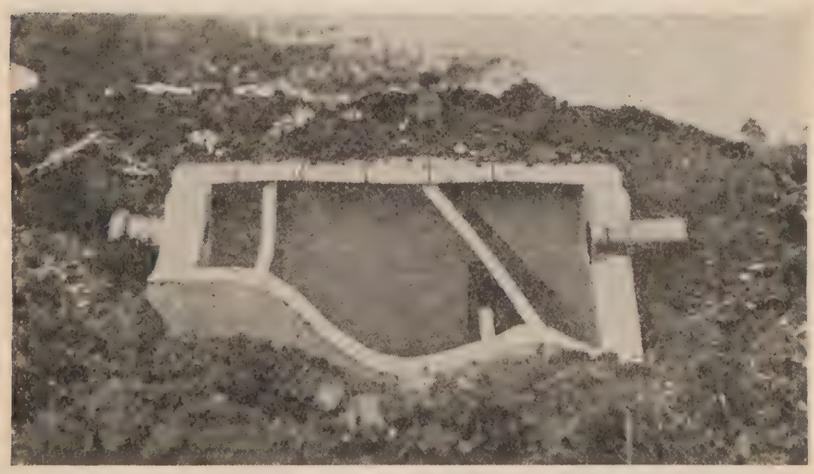
The liquid effluent from the septic tank contains the organic compounds originally in solution, together with an added amount due to the liquefaction of digesting solids in the tank, and a small amount of finely divided suspended matter which will not settle. Only about thirty percent of the putrescible matter is removed in the septic tank, and the sewage


Sewer
Septic Tank
Distributing Box
Purification
Field

leaving the tank contains a large number of bacteria, some of which may be dangerous. Bad odors will develop if the tank effluent is allowed to stand in an open ditch. For these reasons further treatment is necessary.

The second part of the purification process is accomplished by bringing the liquid wastes into contact with bacteria, which receive oxygen from the atmosphere and combine it with the organic matter in sewage as part of their life processes. At the same time these bacteria change the organic matter so that it is available for use as food by growing plants. Countless numbers of bacteria are present in the top few inches of the soil, and when the liquid from the septic tank is spread out by drain tile into the top soil, they complete the purification process. Since the number of bacteria decreases rapidly with depth, it is important that disposal should be near the surface.

The length of drain tile needed depends on the composition of the soil and



CUT-AWAY SECTION OF SINGLE RESIDENCE SEPTIC TANK

the amount of sewage to be disposed of daily. A dry, sandy soil will take more sewage than a heavy soil. In some areas the soil may be so nonabsorptive that the conventional drain-tile system cannot be used. It is important to determine the approximate absorption characteristics of the soil prior to planning the complete system. A method of ascertaining the approximate soil absorption characteristics is outlined in this BULLETIN.

The drain-tile lines should always be laid in clean, coarse gravel or crushed rock (¾″ to 2½″).

The capacity of a given plot of ground to receive sewage is limited, and if the sewage is applied continuously, or if the drainage is not satisfactory, the soil rapidly loses its porosity and there is a failure to oxidize the wastes. Since the bacteria which act on the organic matter must get their oxygen from the atmosphere, the sewage should be applied intermittently so that air can penetrate into the soil between doses. For the ordinary residence there is enough variation in sewage flow to permit the intermittent aëration of the field.

However, when the number of persons served by a disposal plant exceeds ten or when the total sewage flow is greater than 500 gallons per day, it is recommended that the sewage be applied to the field by means of a siphon and dosing tank. This arrangement provides for intermittent dosage and also for better distribution through the tile lines. Whenever sewage appears at the surface of the ground, or when the soil around the tile lines becomes soft and soggy, the field is probably receiving too much sewage. Additional drain lines should be laid to distribute the sewage over a larger area.

The settled sewage is usually applied to the irrigation field by means of plain-end drain tile, three or four inches in diameter, although ordinary sewer pipes can also be used by laying in open joint with the bell ends of the lengths down slope and with spigots centered in the bell. Sewer pipe laid with tight joints should be used for conducting the settled sewage to the irrigation field. The layout of the disposal pipe will depend to some extent upon the shape and slope of the field. Diagrams illustrating different arrangements of irrigation tile are shown in this BULLETIN.

Constructing the System

House Sewer

Essential features to be observed in the construction of the house or building sewer are as follows:

1. Minimum size of pipe: 6 inches, if sewer is of vitrified clay; 4 inches, if sewer is of cast iron.
2. Minimum grade: 1 per cent (1 foot fall per 100 feet or ⅛ inch per foot). However, a fall of ¼ inch per foot is preferable and should be provided wherever feasible.
3. Grade of building sewer for 10 feet immediately preceding the tank should not exceed 2 per cent.
4. Cast iron pipe with lead (or equal) joint material should be used when within:
   (*a*) 50 feet of a well or suction line from a well.
   (*b*) 10 feet of any drinking water supply line under pressure.
   (*c*) 5 feet of basement foundations and when laid beneath driveways.
5. Cleanouts should be provided at every change in line in excess of 45° and at every change in grade in excess of 22½°. (Cleanouts are desirable within 5 feet of the septic tank where tanks are located more than 20 feet from the building. An economical cleanout may be provided by inserting a tee in the line with the vertical leg extending to ground level and plugged with a brass cap. If the line is deeper than about 4 feet, manhole construction would be required for cleanout purposes.)
6. All joints should be made watertight and protected from damage by roots wherever necessary.

Forms

The forms for the septic tank are easily constructed and placed. They have been designed so that they can be removed and reassembled with little difficulty. See figures 1 and 1A for top, bottom, and wall reinforcing. In constructing the forms build up the rectangular box 6 feet long and 3 feet wide, outside dimensions, by 5 feet high. If shiplap is used for the form lumber, the lap on the top and bottom board should be planed off. The forms should then be sawed as shown in the corner detail and the vertical uprights nailed in place. Holes should be drilled for the bolts, counter-boring the holes for the nuts on the outside face of the forms. The mortise should be deep enough

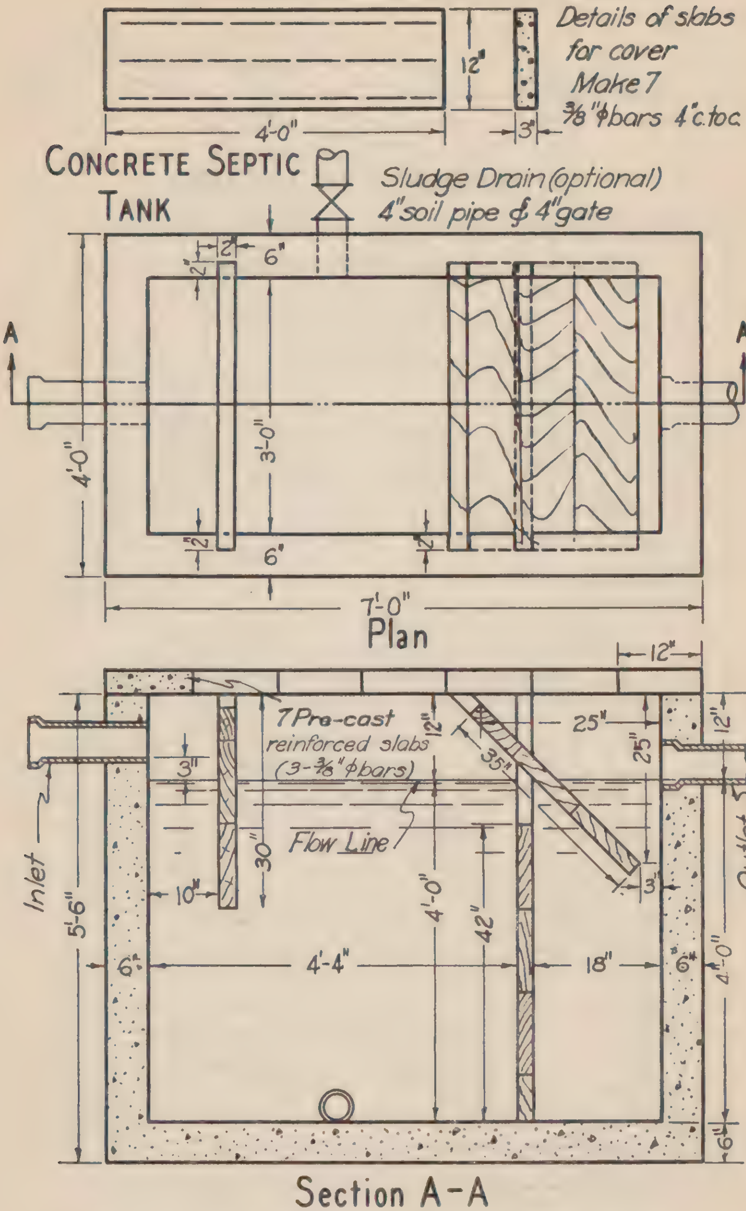


FIG. 1—CONCRETE, SINGLE RESIDENCE SEPTIC TANK
(Reinforce walls and bottom with ⅜" steel rods at 12" centers both ways.)

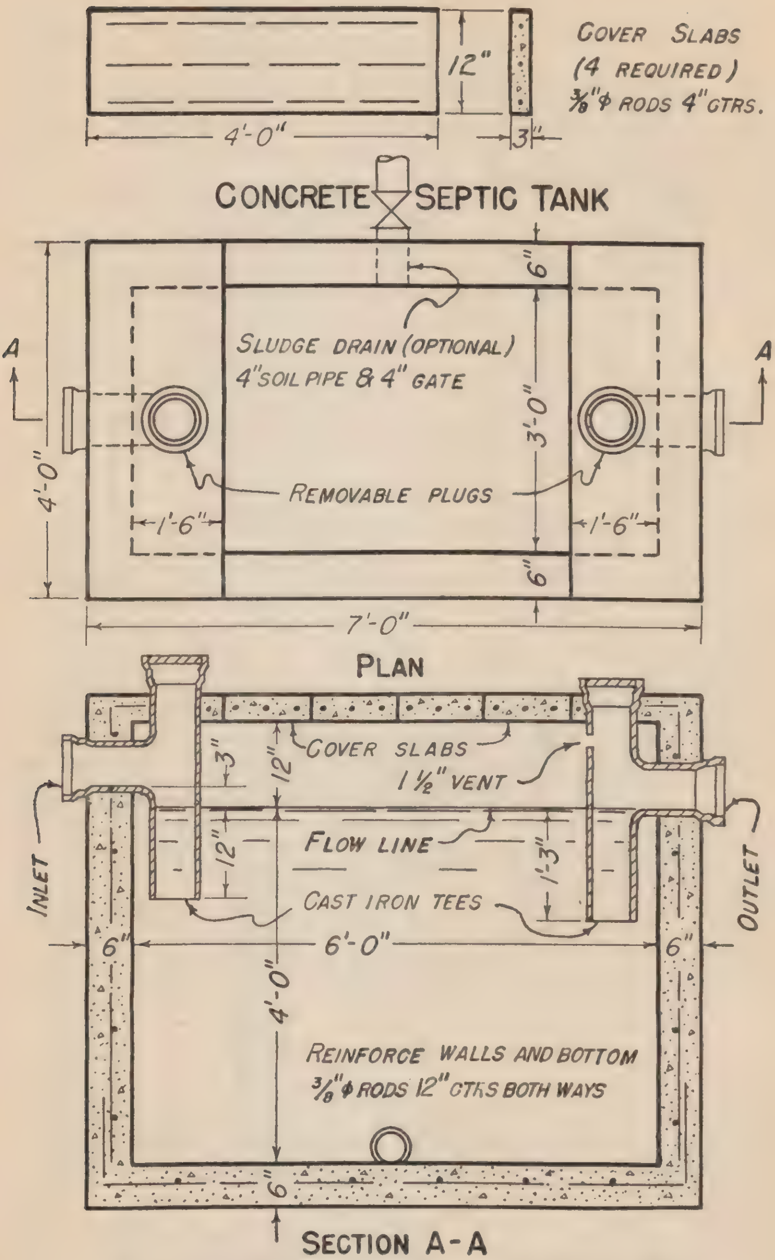


FIG. 1A—CONCRETE, SINGLE RESIDENCE SEPTIC TANK
(Alternate construction with cast iron tees instead of wooden baffles)

to let the nut be flush with the face of the form and the bolts should be tightened from the inside. Six cross-braces should be set in place, two near the top, two at the center, and two in the bottom, as indicated on the plans. The cleats for the baffles should be lightly nailed so that they will pull loose from the forms upon being removed, and they should also be given a slight taper to facilitate their removal from the concrete wall. To prevent adhesion of the concrete to the forms and make their removal easy, the surface coming in contact with the concrete should be well greased. Lubricating oil, used crankcase oil, or soft soap may be used for this purpose, and can be best applied with a brush. The forms, when in place, should be suspended from stringers placed across the excavation as shown in the plans. The forms should be leveled crosswise and lengthwise. See figure 2. **The forms shown in figure 2 are for the tank shown in figure 1. They do not apply to figure 1A.**

Location of Plant

The septic tank may be located as near the building served as practicable, but should be from *50 to 100 feet from the house well,* and so located that all drainage will be away from the well. The subsurface irrigation field should be located in well-drained soil *and as far from the water supply as possible.* It should *never* be located where the ground surface slopes toward the well. The effluent line from the septic tank to the irrigation field should be laid in tight tile. The slope and size of this line should not be less than that indicated for the house sewer.

An electrically driven sump pump may be used to lift basement laundry tray drainage into the house sewer unless other approved means of disposing of this waste can be found. *However, under no circumstances should footing drainage be disposed of through the tank. The amount of the latter would, during wet weather, overload the entire disposal system.* Water operated ejectors should not be used as a substitute for sump pumps.

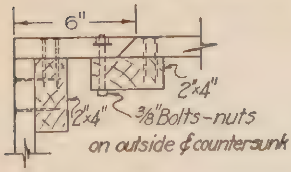
The Septic Tank

As previously pointed out, the septic tank must be large enough to prevent any interruption of the settling of the sewage solids by sudden surges of sewage into the tank. If the capacity of the tank is based on a given volume for each person contributing sewage, the per capita volume will have to be greater in tanks serving a small number of people than for larger plants. For tanks serving hotels, etc., the per capita requirements in volume are less, principally because the amount of incoming sewage at any time is only a small per cent of the total volume of the tank, and will not greatly affect the settling action in the tank.

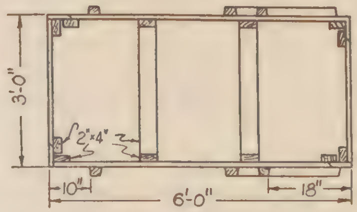
The plans and details of the septic tank shown in figures 1 and 1A have been designed to accommodate a family of five persons or less. **A tank smaller than this size is not recommended.** For schools, hotels, etc., a dosing tank and siphon should be provided as shown in figure 6 or 6A, and the dimensions of the tank should be made in accordance with the figures shown in the tables of sizes.

In constructing the tank shown in figure 1, the inlet and outlet lines should be carefully placed as indicated by the plans. Slots can be provided in the concrete side walls to receive the planks which form the baffles, by nailing

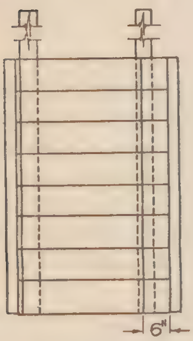
DETAILS OF FORMS
FOR A SINGLE RESIDENCE SEPTIC TANK



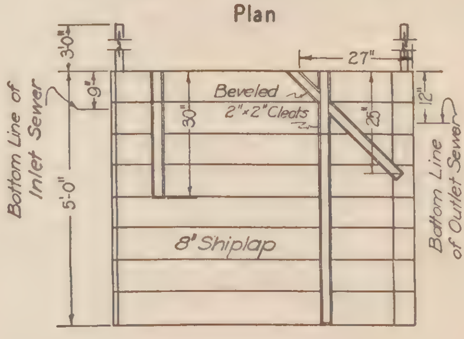
Corner Detail



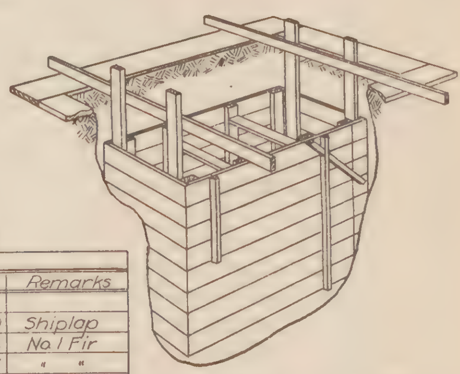
Plan



End Elevation



Side Elevation



A Perspective of Forms in Place

Bill of Materials

No.	Size	Length	Purchase	Bd Ft	Remarks
16	1"x8"	6'-0"			
16	1"x8"	3'-0"	12-1"x8'x12'	96.00	Shiplap
4	2"x4"	8'-0	4-2"x4"x8'	21.34	No. 1 Fir
8	2"x4"	5'-0"	4-2"x4"x10'	26.67	" "
6	2"x4"	2'-7"	2-2"x4"x8'	10.67	" "
2	2"x4"	6'-0"	1-2"x4"x12'	8.00	" "
3	2"x2"	6'-0"	4-2"x2"x6'	8.00	" "
16	3/8"	2 3/4"	16-3/8"x2 3/4"		Machine Bolts
1#	7d				Box Nails
1#	10d				Nails

Total Board Ft 170.68

FIG. 2—FORMS FOR CONCRETE TANK SHOWN IN FIG. 1
(Not applicable to Fig. 1A)

2-in. by 2-in. strips, slightly beveled, on the inside form. A 6-in. by 6-in. port cut in the bottom plank of the vertical baffle will be of assistance in cleaning the tank. The port should be covered with a hinged board on the inlet side to prevent flow through the port when the tank is in operation. The cover is made up of concrete slabs which are cast separately and sealed to the top of the tank with mortar.

Only rot-resistant wood should be used for the baffles. If desired the wooden baffles may be eliminated entirely and cast iron tees substituted for them. If tees are used, they should have the same diameter as the inlet and outlet pipes. The inlet tee should extend 12 inches and the outlet tee 15 to 18 inches below the liquid level in the tank. Both tees should extend at least 6 inches above the liquid level. See figure 1A.

A covering of earth 12 to 18 inches thick will prevent freezing.

The Irrigation Field

The distributor line from the septic tank to the subsurface irrigation field should be at least four inches in diameter, and should be constructed of sewer pipe with tight joints. For the distribution laterals, one-foot lengths of four-inch plain-end drain tile may be used. In small installations the absorption tile are frequently laid out in one line, which is curved to follow the slope of the ground. Better distribution of sewage to the laterals can be obtained by means of a distributing box, however, and this method of application is recommended for most installations. See figure 3.

Special care must be exercised in preparing the trench and laying the absorption tile. The laterals should have very little fall, not more than two or three inches per 100 feet, so that the sewage will not rush to the ends of the lines. The openings between the tiles should not be so large that the sewage will all seep out in the first few feet. Even distribution should be secured. An opening of about one-eighth inch between tiles has been found satisfactory for good distribution. The depth of the trench should be such that the top of the tile is about 15 inches below the top of the ground.

Note the grade board shown in the lower right-hand corner of figure 3. It is essential that grade boards such as shown in figure 3 be used when laying the drain tile so as to maintain true line and grade. (2″ - 3″ per 100′.) It is impossible to lay drain tile to true line and grade without the use of a suitable guide. Failure to maintain true line and grade will result in poor irrigation field performance.

Tar paper or better, roll roofing collars should be provided over the top half of the joints to keep fine material from sifting into the line. Special care in trench construction is needed to secure as much absorption per foot-length of tile as possible. The trench should be dug two feet wide and not more than about 24 inches deep. It should then be filled to a depth of six inches with material such as clean, coarse, crushed rock or gravel and the tile laid. The top half of the joint should be covered with the collar and coarse rock crowned over the collar to hold it in place. Be careful to avoid disturbing the tar paper collars. Before backfilling the remainder of the trench with earth, cover the rock with a 2″ layer of straw or *untreated* building paper. This will help prevent the earth from sifting into the voids in the rock surrounding the tile.

The irrigation field should be located so that it will be some distance from

trees, since the moisture draining from the tile will attract the roots and cause the line to clog. Where trouble of this kind develops it is necessary to dig up the entire line and clean the roots out of the tile.

Percolation Test

In order to determine the approximate length of irrigation tile needed, it is first necessary to run a percolation test which will give some idea as to the absorption qualities of the soil at the irrigation field site. This test, which should not be run in filled or frozen soil, is made as follows:

(1) Excavate a hole 1 foot square and to the depth of the proposed disposal trenches. This depth in most instances will be approximately 24 inches.

(2) Fill the hole with water to a depth of 6 inches and note the time. Allow the water to seep away *completely* and again note the time.

(3) Compute the average time in minutes required for the water to fall one inch by dividing the time in minutes for the 6 inches of water to seep away completely by 6.

(Judgment is required in interpreting the results of this test. Where the soil appears exceptionally dry or where soil conditions are questionable, a greater depth of water may be used or the test may be repeated. In no case should tests be made in filled or frozen ground. Where fissured soil formations are encountered, tests should be made only as directed by and under the supervision of the state or local health department. When in doubt get in touch with the state or local health department. For large irrigation tile fields several tests should be run at various points in the field and the results averaged.)

With the information obtained from the percolation test, the number of feet of open joint tile lines laid in trenches 2 feet wide can be computed from the following table. **This table applies only to single residence installations serving not more than 5 persons.**

TABLE 1

Result of Percolation Test: Average time required for water to fall 1 inch.	Feet of open-joint tile, laid in a trench 2 feet wide, required for single residence installation serving not more than five persons.
10 minutes or less	150* to 200 feet
11 to 15 minutes	200 to 250 feet
16 to 30 minutes	250 to 350 feet
31 to 60 minutes	350 to 500 feet
Over 60 minutes	Unsuitable. Special design required. Consult state or local health department.

The Distributing Box

The purpose of the distributing box is to secure even distribution of the sewage to the various lateral lines which make up the subsurface irrigation field. The feed line from the septic tank to the distributing box is laid with tight joints. The laterals are fed by separate lines from the distributing box, which are laid with tight joints from the box to the laterals. *It is important that the outlet pipes from the box be at the same elevation so that the flow will be divided equally between the lines.* This method of distribution should always be used when the irrigation field is located on a slope and the various

* Never provide less than 150 feet. It pays to provide plenty of tile line.

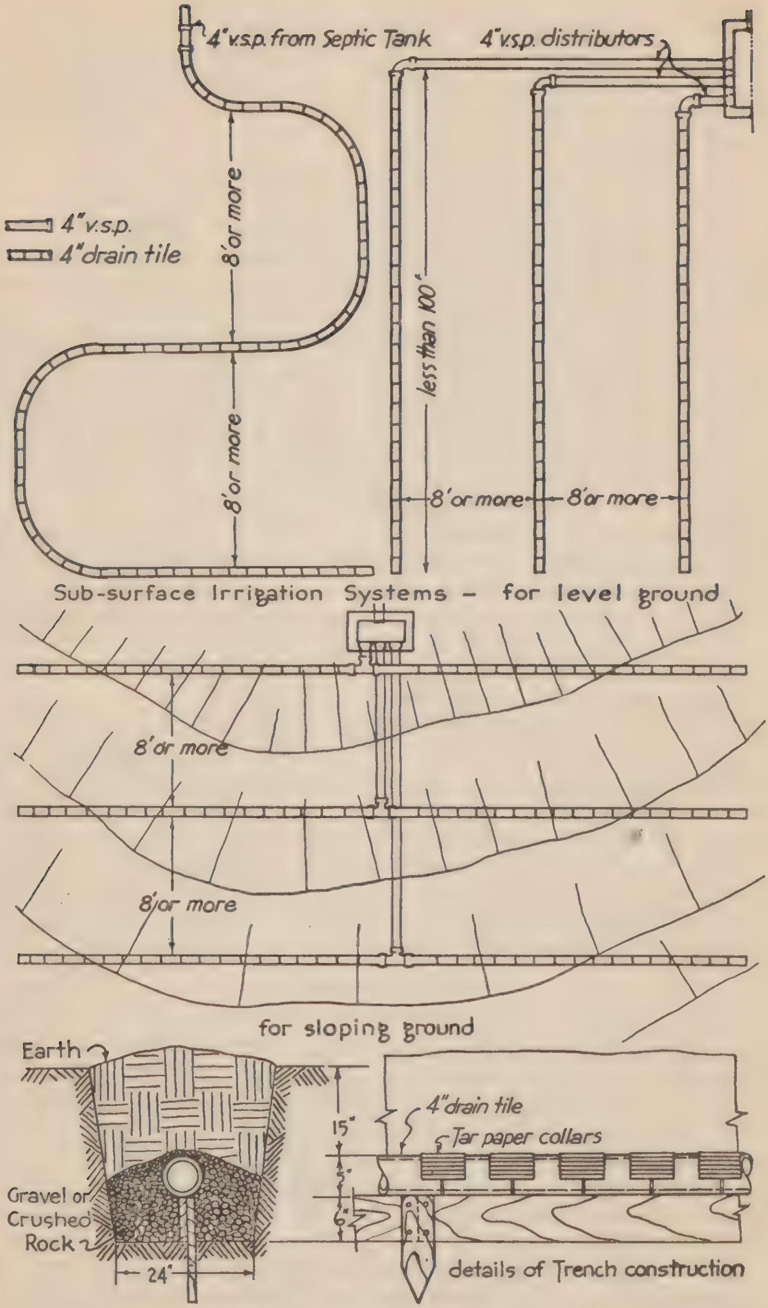


FIG. 3—IRRIGATION FIELD CONSTRUCTION

lateral lines are at different elevations. Illustrative arrangements of tile lines and types of distributing boxes are shown in figures 3 and 4.

Sometimes it is desirable to cut off the flow to a part of the tile lines for several days in order to rest that portion of the field. With the distributing box this can be accomplished by closing the openings with "stop boards" braced across the box. See figure 4.

The Operation of the Plant

Properly installed, the septic tank and subsurface irrigation system require little attention. **The plant should not be forgotten, however, since continued neglect will result in the clogging of the drain tile, making expensive replacement of the irrigation field necessary.**

The frequency with which the tank should be cleaned depends upon the quantity of solids going into the tank. Some tanks must be cleaned every year, while others will operate for five years or more without being cleaned. At least once every two or three years the tank should be opened and the depth of sludge and scum measured. When the sludge in the bottom of the tank exceeds 12 inches in depth, it should be pumped out. The scum is usually quite hard and can be removed with a pitchfork or shovel.

When the tank is on a side-hill location a sludge drain, as shown in figure 1, can be provided. This greatly facilitates the cleaning of the tank. For final disposal, the sludge can be drawn off into a shallow pit and buried, or if the tank is located some distance from the house it can be lagooned on the surface of the ground until dry. The dried sludge can then be spread on the land. When pumping out or draining a tank, the contents should be kept agitated so that the sludge will be drawn off with the liquid.

The subsurface irrigation field should be watched for indications of clogging of the tile. When a distributing box is used with several lateral lines, these should be observed to see that each line is receiving its full portion of sewage. The appearance of sewage at the surface of the ground over a lateral indicates that the line is receiving more than its proportion, and the flow to this line should be cut off at the distributor box by means of a stop plank to permit it to rest for a while. If it appears that the entire system is overloaded, the tile lines should be extended at once. Continued negligence will result in the clogging of the soil and the field will become waterlogged and sour.

Care and Maintenance

(1) Only standard toilet paper should be used in house fixtures. Newspaper, rags, sticks, and garbage should be kept out of the sewer. Disposal of this material into the system may cause a stoppage of the line and will take up space in the septic tank which is needed for the digestion of sewage solids.

(2) Grease should not be poured into any plumbing fixture. When it cools the grease congeals in the lines, and large quantities of grease in the septic tank interfere with its operation. Where large quantities of grease are to be handled, properly constructed grease traps should be installed to prevent it from entering the septic tank.

(3) Chemicals or disinfectants should not be discharged into the septic tank. Chemicals, either acid or alkaline compounds, interfere with the bacterial action in the septic tank and will cause the tile lateral field to clog much more

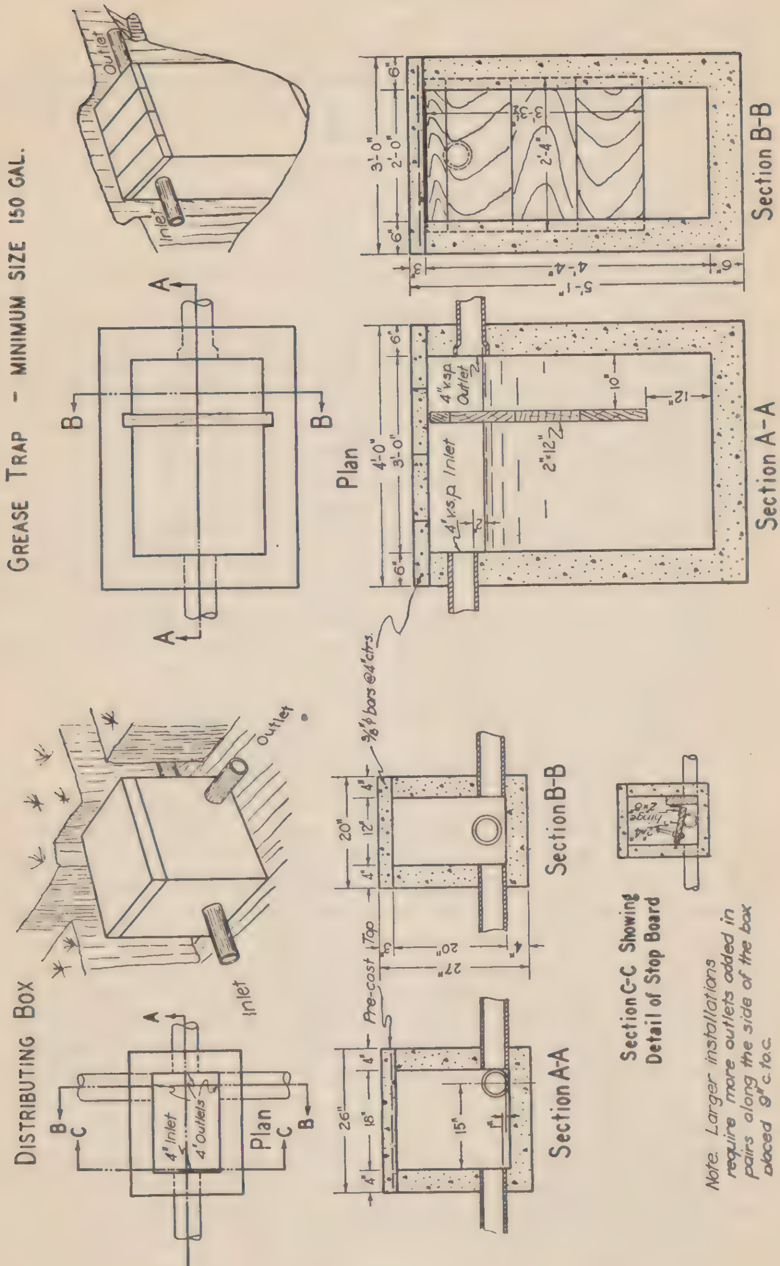

GREASE TRAP - MINIMUM SIZE 150 GAL.
Outlet
Inlet
Plan
4" v.s.p. Outlet
4" v.s.p. Inlet
2"x12"
Section A-A
Section B-B
3/8" φ bars @ 4" ctrs.
DISTRIBUTING BOX
4" Inlet
4" Outlets
Plan
Pre-cast Top
Section A-A
Section B-B
Section C-C Showing Detail of Stop Board
Note. Larger installations require more outlets added in pairs along the side of the box placed 9" c. to c.

FIGURE 4

rapidly. Chemicals should not be used to try to dispose of the solid matter in the septic tank.

(4) Roof drains should not be connected to the system.

(5) Inspect the tank every two or three years to ascertain whether or not cleaning is necessary. The tank should be cleaned when the sludge in the bottom exceeds twelve inches in depth.

(6) Grease traps must be cleaned periodically if they are to remove grease effectively. If the trap is permitted to fill, the grease entering the trap will be carried on into the septic tank.

(7) Remember that the maintenance and care given the septic tank and the tile field will determine the results that you get from the system.

Grease Traps

Grease traps are not necessary for small-residence installations. However, adequate grease traps should be provided for restaurants, hotels, schools maintaining kitchens, large residences, etc. The installation of a grease trap requires running a separate line from the kitchen sink to the grease trap and then connecting the outlet of the trap to the main sewer line leading to the septic tank. In order for the grease trap to remove grease effectively, it must be of sufficient size to permit the water entering it to cool so the grease can rise to the water surface and be retained in the trap while the remainder of the sink wastes pass on into the septic tank. A sketch of a 150 gallon grease trap of simple design is shown in figure 4. This particular size is the minimum recommended and will not be large enough for all installations.

Under no circumstances should any sewage other than the kitchen wastes be permitted to discharge to the grease trap.

Grease traps should be easily accessible and must be inspected frequently and cleaned often enough to maintain them in good operating condition.

Septic Tank with Siphon Dosing Apparatus

For installations larger than the average residence a dosing tank and siphon should be used in connection with the septic tank. See figures 6 and 6A.

The purpose of the automatic siphon is to secure even distribution of the sewage over the irrigation field and to provide a rest period between doses.

In operation, the sewage from the septic tank is caught in a siphon chamber or dosing tank, usually attached to the septic tank. When the liquid level reaches a certain depth, forcing the seal on the automatic siphon, the siphon goes into operation and the contents of the dosing tank are emptied quickly into the irrigation line. When the dosing tank is nearly empty the siphon reseals and shuts off the flow. The chamber must then refill before the siphon will again go into action. The capacity of the siphon chamber is based on the amount of irrigation tile used, being large enough to hold about ½ to ¾ of the contents of the tile.

Automatic siphons may be obtained from various manufacturers. In making installations the manufacturer's directions for setting the equipment should be followed carefully. Allowance must be made for the extra head required when the siphon is used. This amounts to a few inches more than the drawing depth of the siphon.

Sewage Filters

Treatment of the septic tank effluent by means of sand filters is practicable for schools, etc., when conditions are not favorable for subsurface irrigation or where the volume of sewage is too great for this method of disposal.

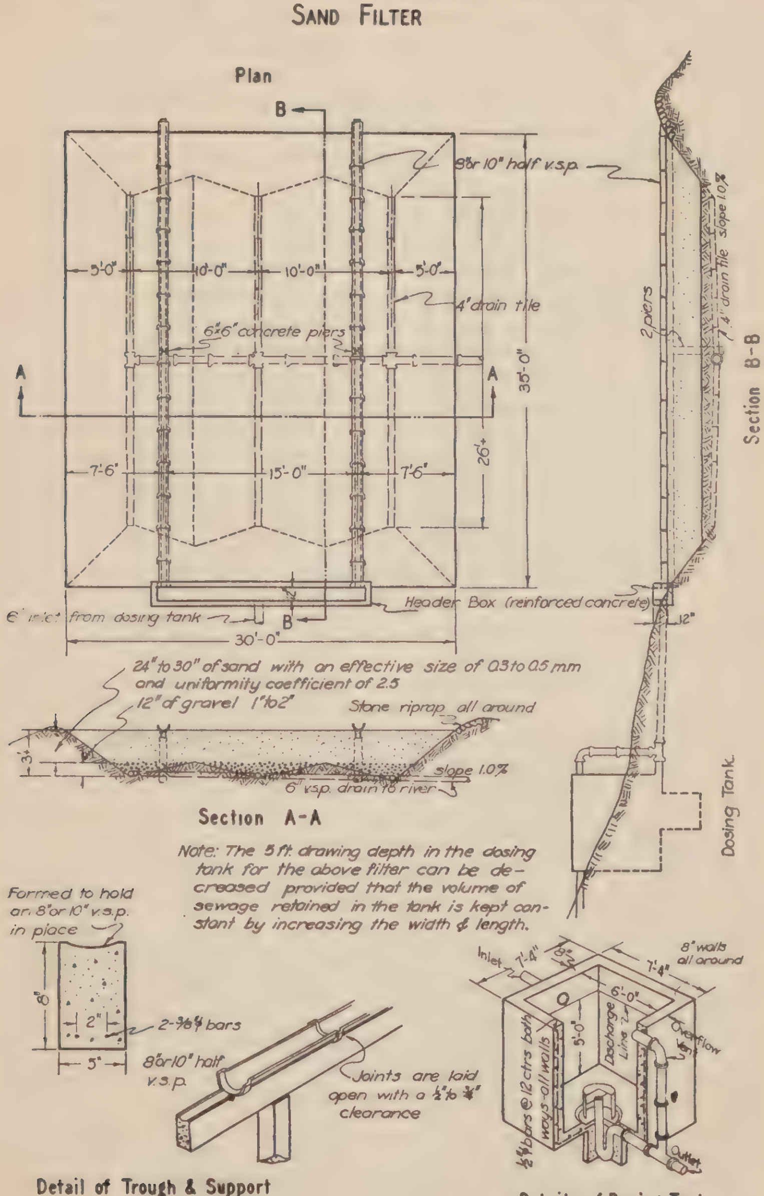


FIGURE 5

The filter consists of an underdrained sand bed about 30 inches deep. Sewage from a dosing tank is applied to the surface of the sand, and after percolating through the bed, is collected in the underdrains and conducted to the point of disposal. In addition to the mechanical straining action of the sand, purification is accomplished by bacterial action in the bed the same as in the top soil where subsurface irrigation fields are used. Usually the sand beds are enclosed by concrete or masonry walls, although sloping earth embankments may be used. A tight bottom is not required if the earth is firm, it being necessary only to slope the earth to the underdrains. These should be covered with graded gravel to a depth of about 12 inches so that the sand in the bed will not seep into the underdrains, causing them to clog. Often local sand can be used for the filter, although it is important that it be clean and not contain an excess of fine material. Sand having a uniformity coefficient of less than 2.5 and an effective size of 0.3 mm. to 0.5 mm. is satisfactory.

The dosing tanks indicated in the tables are not large enough for a filter-bed installation. The size of a recommended dosing chamber is indicated in figure 5. This has been computed for a bed of 1,000 square feet and the size would have to be increased for larger installations. The dosing tank must be of sufficient size that when the sewage is run onto the filter bed it theoretically would cover the filter to a depth between two and three inches.

It is often desirable to have the sand filter divided into two sections. This makes it possible to take one section of the bed out of service for resting or cleaning. The bed can be divided by running a 12-inch plank set on edge across the center and distributing the sewage on each section of the filter. The sewage distribution can be accomplished by means of a distribution box or by providing two siphons in the dosing chamber. Where more than one siphon is used the header walls at the face of the filter should also be divided and separate lines run from each siphon in the dosing tank to the header so that each filter will be dosed alternately.

The siphon should discharge at a rate of one cubic foot per second, or 450 gallons per minute, for each 5,000 square feet of bed area. Thus, for the 1,000 square feet of filter-bed area shown in the plant, a siphon discharging at a rate of 90 gallons per minute would be desired. If the bed were divided in two and individual siphons installed for each filter bed, the discharge rate should then be cut in half and the size of the dosing tank also decreased so that the depth of the sewage on the filter would not be increased. The underdrains should have a fall of six inches per 100 feet and the half-tile distribution troughs on the surface of the bed should have only sufficient fall to cause the liquid to flow.

There are certain limitations to the use of a sand filter which should be taken into account. From 50 to 60 inches of fall (or head) are required between the sewage level in the septic tank and the filter underdrains. The sand beds require some area, and in built-up sections such a plant may become somewhat of a nuisance unless properly cared for. Generally speaking, open sand filters are not economical for installations serving less than about 20 people.

Operating care is necessary for good results. In no case should the sewage be allowed to stand in ponds on the sand. After the filter has been in use for a time the sludge accumulations will seal the surface of the bed, and it will

be necessary to scrape off the sludge. Each cleaning will result in some loss of sand, which must be replaced from time to time. After each cleaning operation the sand should be loosened to a depth of three or four inches and the surface carefully leveled. During the winter months the filter may be ridged. As sewage is discharged onto the filter in freezing weather it will fill the furrows. Ice will gradually span the ridges, and the sides and bottoms of the furrows will remain open.

The plan of the sand filter included in this bulletin has not been designed for any particular location, and it is recommended that an engineer be consulted where this type of treatment is necessary or desirable.

Sand filters should be installed only where regular operating attention is assured.

Table of Plant Sizes

The following tables indicate tank dimensions, and length of subsurface irrigation tile or area of sand filter for various sizes of plants. It will be noted that siphons are recommended for all installations except the ordinary residence plant. The recommended length of drain tile in each case is based on careful trench construction.

Reasonably good soil absorption conditions have been assumed in the tables of plant sizes. However, it is recommended that before the drain tile field is constructed percolation tests be run in accordance with instructions previously given in this BULLETIN, in order to gain an approximate idea of the actual characteristics of the soil at the plant site. The values for linear feet of 4-inch drain tile and the dosing tank area given in the tables of plant sizes should then be modified, if necessary, by the following factors:

TABLE 2

Result of Percolation test, (Average time for water to fall 1 inch.)	Multiply length of 4-inch drain tile* given in tables 3 and 4 by:
10 minutes or less	(Use figure in table)
11 to 15 minutes	1.3
16 to 30 minutes	1.7
31 to 60 minutes	2.5
Over 60 minutes	(Conventional tile field cannot be used)

If it is found necessary, as a result of the percolation test, to use more tile than specified in tables 3 and 4, the volume of the dosing tank (siphon chamber) should also be increased. Usually the best way to provide additional volume in the dosing tank will be to increase its area by increasing the length (E). The factor obtained from table 2 applies also to the dosing tank volume increase. For example, if the percolation tests give an average result of 13 minutes as the average time for the water to fall one inch, and the plant is being constructed to serve a large residence accommodating 15 persons, then by referring first to table 2 and then to table 3 it will be found that the length of 4-inch tile drain line needed will be $1.3 \times 500 = 650$ feet. The length of the dosing tank should, therefore, be changed to $3.5 \times 1.3 = 4.5 = 4$ feet 6 inches in order to serve the increased length of tile line. The depth of the dosing tank should not be altered.

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* Laid in a trench at least 2′ wide and surrounded by coarse stone. See Fig. 3.

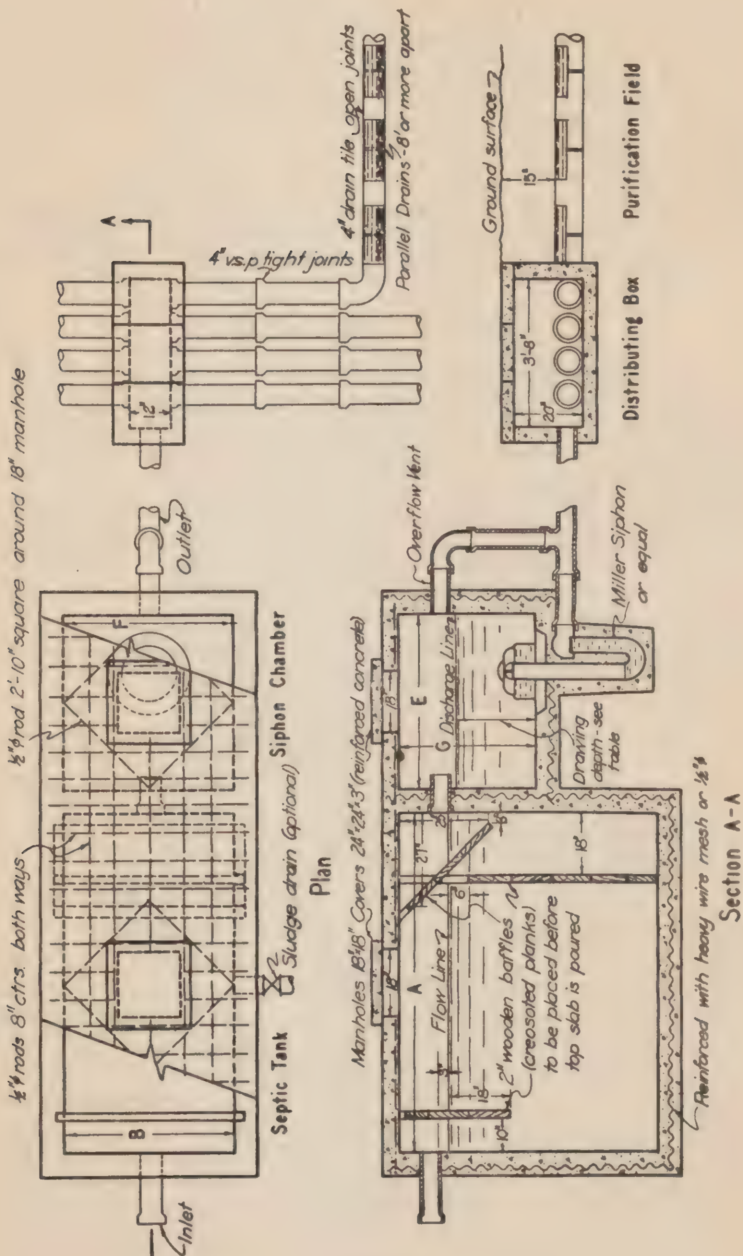
½"φ rods 8" ctrs. both ways
½"φ rod 2'-10" square around 18" manhole
Outlet
Inlet
Septic Tank
Sludge drain (optional)
Siphon Chamber
Plan
4" v.s.p. tight joints
4" drain tile open joints
Parallel Drains - 8' or more apart
Ground surface
15"
3'-8"
20"
12"
Distributing Box
Purification Field
Manholes 18"x18" Covers 24"x24"x3" (reinforced concrete)
Overflow Vent
Miller Siphon or equal
Discharge Line
Drawing depth - see table
Flow Line
2" wooden baffles (creosoted planks) to be placed before top slab is poured
Reinforced with heavy wire mesh or ½"φ
Section A-A

FIGURE 6

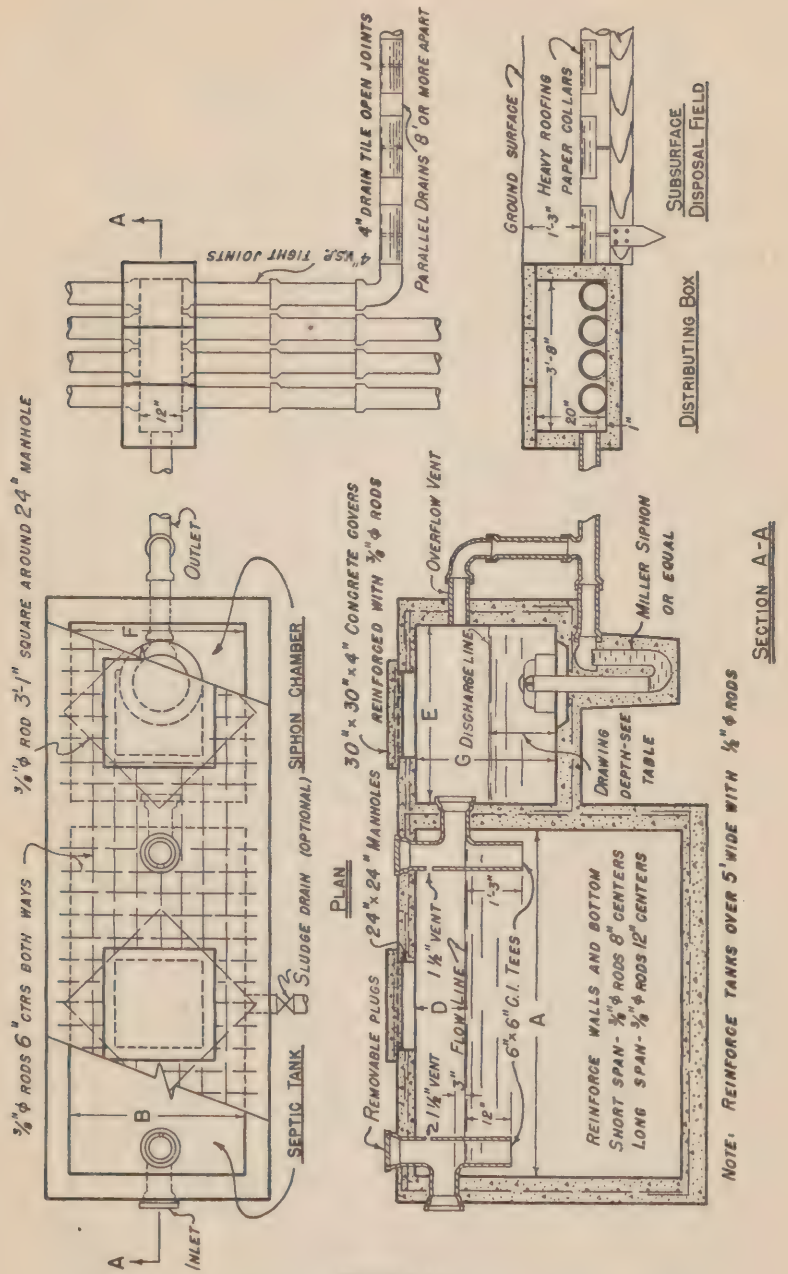

FIGURE 6A
(Alternate construction with cast iron tees instead of wooden baffles)

TABLE 3

TABLE OF SIZES FOR RESIDENCES, HOTELS, ETC.

Number of persons.	Capacity of septic tank.	Dimensions.							Thickness of concrete.			Siphon.*		Linear feet of 4-inch drain tile. (See Table 2).	Area of sand filter recommended.
		Septic tank.				Dosing tank.*									
		Length A.	Width B.	Liquid depth.	Air space D.	Length E.	Width F.	Depth G.	Walls.	Top.	Bottom.	Size.	Drawing depth.		
	Gal.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	In.	In.	In.	In.	In.		Sq. ft.
5 or less	500	6 0	3 0	4 0	1 0	....	....	....	6	3	6	....	....	150–200†	....
6–8	730	7 0	3 6	4 0	1 0	2 9	3 6	3 0	6	4	6	4	17	250	....
9–11	950	8 0	4 0	4 0	1 0	3 0	4 0	3 0	6	4	6	4	17	325	....
12–20	1,160	8 6	4 6	4 3	1 0	3 6	4 6	3 0	6	4	6	4	17	500	580
21–30	1,360	9 0	4 6	4 6	1 0	5 0	4 6	3 0	8	4	6	4	17	750	680
31–40	1,700	9 9	5 0	4 9	1 3	5 0	5 0	3 6	8	4	6	5	23	1,000	850
41–50	2,000	11 0	5 0	5 0	1 3	5 6	5 0	3 6	8	4	6	5	23	1,250	1,000

* If sand filters are used make dosing tank large enough to cover sand beds to depth of 2 inches at each dose.

† Trenches should be at least 2 feet wide. Tile surrounded by coarse stone.

NOTE.—For tanks wider than 4 feet use solid top slab, reinforced as shown in Figure 6. Use wall and bottom reinforcing as shown in Figure 4 for tanks greater than 9 feet in length.

Do not use figures given for linear feet of 4-inch drain tile without first running percolation test and referring to table 2 and the discussion pertaining to it.

TABLE 4

TABLE OF SIZES FOR SCHOOLS, ETC., REQUIRING ONLY EIGHT-HOUR-DAY SERVICE (WITH SHOWERS)

Number of persons.	Capacity of septic tank.	Dimensions. Septic tank. Length A.	Septic tank. Width B.	Septic tank. Liquid depth.	Septic tank. Air space D.	Dosing tank.* Length E.	Dosing tank.* Width F.	Dosing tank.* Depth G.	Thickness of concrete. Walls.	Thickness of concrete. Top.	Thickness of concrete. Bottom.	Siphon.* Size.	Siphon.* Drawing depth.	Linear feet of 4-inch drain tile. (See Table 2).	Area of sand filter recommended.
	Gal.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	In.	In.	In.	In.	In.		Sq. ft.
50 or less	1,000	8 6	4 0	4 0	1 0	4 0	4 0	3 6	6	4	6	5	23	450†	500
51–100	2,000	11 0	5 0	5 0	1 3	4 3	5 0	3 6	8	4	6	5	23	900	1,000
101–200	4,000	15 6	7 0	5 0	1 3	5 6	7 0	3 6	9	5	6	5	23	1,800	2,000
201–300	6,000	20 0	8 0	5 0	1 6	7 0	8 0	3 6	10	5	6	5	23	2,700	3,000
301–400	8,000	22 3	8 0	6 0	1 6	10 0	8 0	3 6	10	5	6	5	23	3,600	4,000
401–500	10,000	28 0	8 0	6 0	1 6	12 6	8 0	3 6	10	5	6	5	23	4,500	5,000

* If sand filters are used make dosing tank large enough to cover sand beds to depth of 2 inches at each dose.

† Trenches should be at least 2 feet wide. Tile surrounded by coarse stone.

NOTE.—Reinforce top slab, side walls, and bottom, as shown in Figure 6.

Do not use figures given for linear feet of 4-inch drain tile without first running percolation test and referring to table 2 and the discussion pertaining to it.

The tank capacities, etc., given in tables 3 and 4 are based on an average sewage flow of about 50 gallons per person per 24 hour day for hotels, residences, etc., and 20 gallons per person per 8 hour day for schools. The sizes given in the table are the *minimum* recommended. However, if the sewage flow is appreciably greater, tank capacities, etc., should be increased accordingly. *For large installations, it is recommended that an engineer be engaged to study the design and prepare detailed plans and specifications.*

Material Required for Septic Tank

(Single residence installation)

Lumber and nails. (See Figure 2.)

Concrete materials:

18 bags cement.
1¼ cu. yd. sand.
2 cu. yds. gravel or crushed rock up to ¾-inch size.

Steel:

21 ⅜-in. round rods 3 ft. 8 in. long.

Fittings:

1 joint pipe for inlet (same size as house sewer).
1 joint vitrified sewer pipe for outlet.

Wood Baffles:

2 pieces 2 in. by 12 in., 14 ft. long. (Rot-resistant wood.)
1 piece 2 in. by 6 in., 8 ft. long. (Rot-resistant wood.)
(Tees may be substituted for the wooden baffles. See Figure 1A.)

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